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# Influence of Elevated Temperature on Compressive Strength and Split tensile Strength of Fiber Reinforced Concrete

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***Abstract***
*In present scenario concrete is being used widely in the construction that might be exposed to elevated temperatures. Different materials were used in the concrete mixes of M 50 have been designed along with crimped steel fibers from 0.5-4% by weight of ordinary Portland cement and river sand was used. Specimens were made and subjected to room temperature, 100, 200, 300, 400 and 500°C. In this study the relation between compressive and split tensile strength value is discussed. Regression analysis is used to obtain this type of relation. This exploration developed some significant data on the properties of concrete exposed to elevated temperatures up to 500°C.*

**Keywords:** *Steel fiber, Split tensile Strength, compression, elevated temperature,*

## INTRODUCTION
Innovative technique of reinforced concrete structures subjected to fire has been discussed by researchers in various ways. This demonstrates much attention towards the development of fire-resistant structures. Therefore, with the low probability of fire occurrence, prescriptive design concepts provided by many codes and standards around the world can lead uneconomical designs. Fibers have widely been used to improve the ductility of concrete. Also more concentration is given to the mechanical properties of concrete after being exhibited to elevated temperatures. Due to negligence of the interaction between the different reinforced concrete members in an assembly or an entire building subjected to fire can lead to unsafe designs. Hence, performance based design has increasingly become a major means of attaining safe, and economic designs for fire-resistant structures.

## PROBLEM DESCRIPTION
### Steel Fibers:
Steel fibers following to ASTM A 820 type -I are used for experimental work and for all the specimens. Fibers are high tensile steel cold drawn wire and specially made for use in concrete. The length of fibers is 50mm and with average aspect ratio 50. The steel fiber has bright appearance of clean wire and has a tensile strength of value 1000Mpa.

### Experimental Program:
The Ordinary portland cement affirming to IS 12269 were used with the fine and coarse aggregates approving to IS 383. The fineness modulus of sand was 2.803 and that for coarse aggregates were 7.52. The M-50 grade of concrete having mix ratios 1: 1.472: 3.043: 0.35 i.e. Cement: Fine aggregate: Coarse aggregate (10mm and 20mm) with ratio of 0.35 was used for complete experimental program.

## RESULT AND DISCUSSION

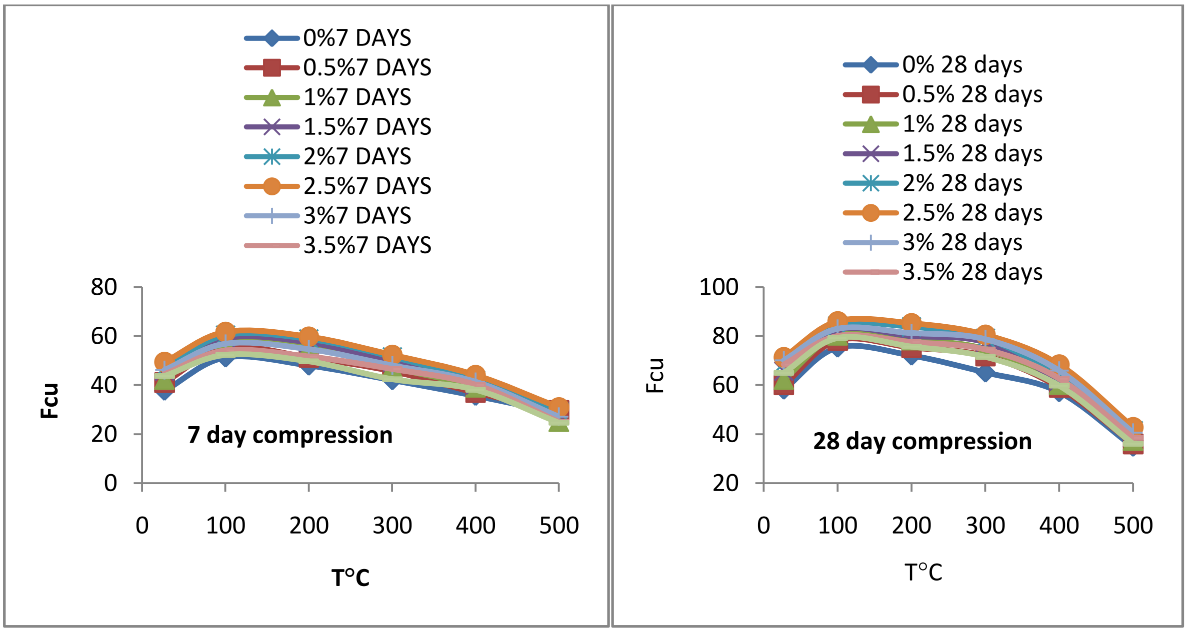
Concrete is not an identical material and structurally concrete may be said that the particles of coarse aggregate are held together in a cement-sand mortar matrix. The concrete is manufactured under strict laboratory control, because of its different structure properties a certain amount of variation in the test results is to be expected. Therefore the results and discussion may be combined into a common section or separately. The test results of compression and split tensile strength are listed in the following tables and with the test results different graphs are plotted with a fiber interval of 0.5-4%.

***Table .1** Compression strength 7& 28 days strength*

| % steel fiber | 7& 28 days compressive strength | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Temperature °C | | | | | | | | | | | |
| | 27 | | 100 | | 200 | | 300 | | 400 | | 500 | |
| | 7 day | 28 day | 7 day | 28 day | 7 day | 28 day | 7 day | 28 day | 7 day | 28 day | 7 day | 28 day |
| 0 | 37.82 | 58.27 | 51.38 | 75.42 | 48.04 | 72.13 | 42.13 | 65.2 | 35.73 | 57.2 | 28.62 | 34.98 |
| 0.5 | 41.11 | 60.13 | 55.42 | 78.36 | 51.33 | 75.33 | 45.73 | 71.96 | 37.02 | 59.11 | 29.87 | 36.04 |
| 1 | 42.4 | 62.4 | 58.44 | 80.4 | 55.91 | 78.4 | 47.2 | 74.8 | 39.16 | 60.31 | 25.11 | 37.42 |
| 1.5 | 45.78 | 65.73 | 59.24 | 82.62 | 57.42 | 80.13 | 49.42 | 77.51 | 40.22 | 61.73 | 27.73 | 39.42 |
| 2 | 47.2 | 69.02 | 60.49 | 84.27 | 58.93 | 83.82 | 51.6 | 79.2 | 42.13 | 63.6 | 29.2 | 41.42 |
| 2.5 | 49.47 | 71.42 | 61.73 | 86.13 | 59.82 | 85.33 | 52.4 | 80.62 | 44.22 | 68.44 | 31.02 | 42.84 |
| 3 | 46.22 | 70.13 | 57.02 | 83.11 | 54.8 | 81.33 | 48.13 | 78.8 | 41.42 | 65.96 | 27.2 | 40.62 |
| 3.5 | 44.53 | 68.53 | 54.2 | 80.13 | 51.73 | 77.6 | 46.62 | 74.62 | 40.22 | 62.71 | 25.11 | 38.53 |
| 4 | 43.82 | 65.11 | 52.4 | 79.33 | 49.73 | 75.82 | 42.44 | 71.6 | 38.22 | 59.82 | 24.71 | 36.13 |

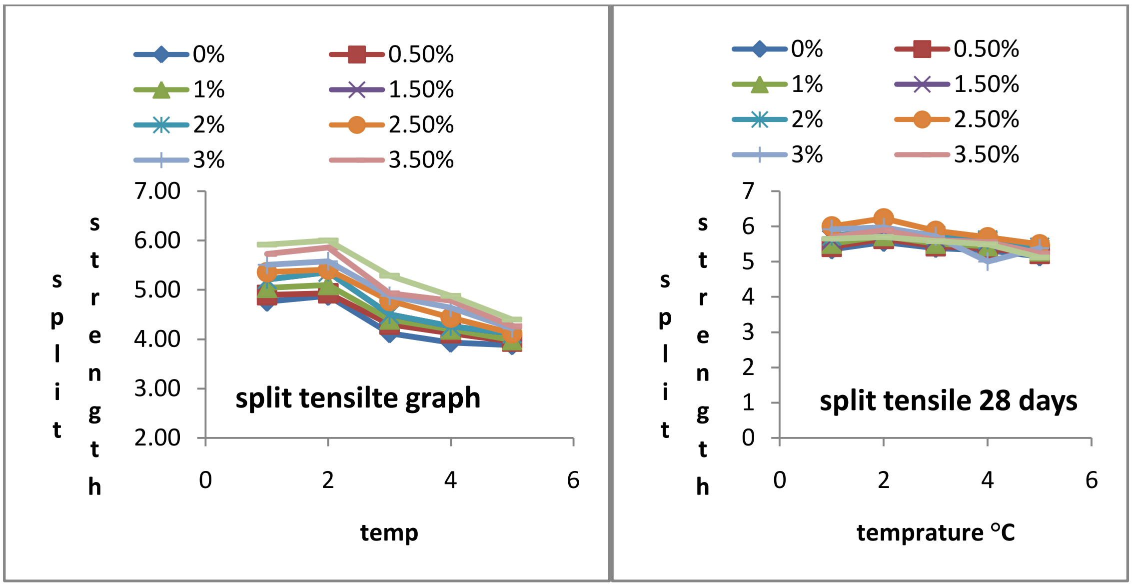
***Table .2** Split Tensile strength 7& 28 days strength*

| **% steel fiber** | 7 & 28 days split tensile strength | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Temperature °C | | | | | | | | | | | |
| | 27 | | 100 | | 200 | | 300 | | 400 | | 500 | |
| | 7 day | 28 day | 7 day | 28 day | 7 day | 28 day | 7 day | 28 day | 7 day | 28 day | 7 day | 28 day |
| 0 | 4.76 | 5.35 | 4.88 | 5.56 | 4.12 | 5.39 | 3.93 | 5.32 | 3.88 | 5.15 | 3.74 | 4.93 |
| 0.5 | 4.90 | 5.42 | 4.93 | 5.65 | 4.30 | 5.44 | 4.12 | 5.38 | 3.95 | 5.22 | 3.81 | 4.98 |
| 1 | 5.04 | 5.51 | 5.10 | 5.73 | 4.40 | 5.51 | 4.20 | 5.44 | 3.98 | 5.29 | 3.84 | 5.04 |
| 1.5 | 5.21 | 5.62 | 5.36 | 5.86 | 4.50 | 5.66 | 4.26 | 5.58 | 4.11 | 5.35 | 3.92 | 5.21 |
| 2 | 5.36 | 5.72 | 5.41 | 5.92 | 4.78 | 5.75 | 4.44 | 5.62 | 4.12 | 5.41 | 3.96 | 5.36 |
| 2.5 | 5.51 | 6.00 | 5.58 | 6.10 | 4.88 | 5.87 | 4.64 | 5.69 | 4.22 | 5.49 | 4.09 | 5.39 |
| 3 | 5.73 | 6.10 | 5.86 | 6.23 | 4.93 | 5.92 | 4.78 | 5.73 | 4.26 | 5.58 | 4.12 | 5.44 |
| 3.5 | 5.92 | 6.22 | 6.00 | 6.31 | 5.29 | 6.01 | 4.88 | 5.87 | 4.40 | 5.66 | 4.20 | 5.51 |
| 4 | 5.42 | 5.65 | 5.49 | 5.70 | 4.88 | 5.65 | 4.44 | 5.49 | 4.12 | 5.12 | 3.95 | 4.90 |



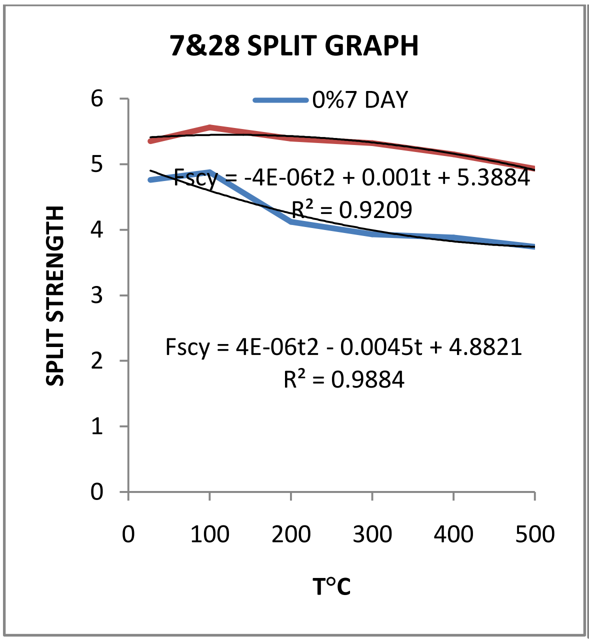

***Graph 1*** ***Graph 2***

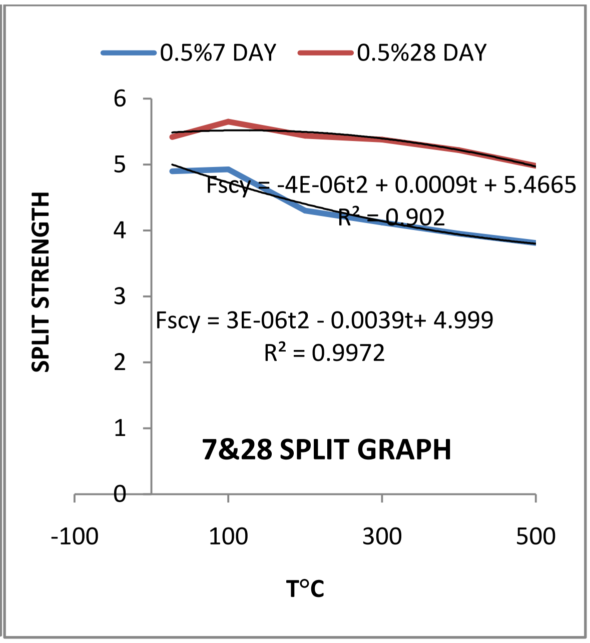
***Fig.1. Graph 1** Compression strength 7 days strength **Graph 2** Compression strength 28 days strength*




***Graph 3*** ***Graph 4***

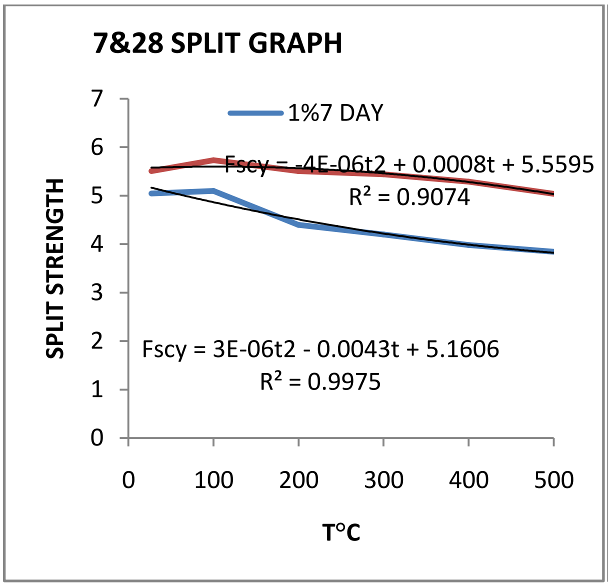
***Fig.2. Graph .3**Split Tensile strength 7days strength. **Graph .4** Split Tensile strength 28days strength*

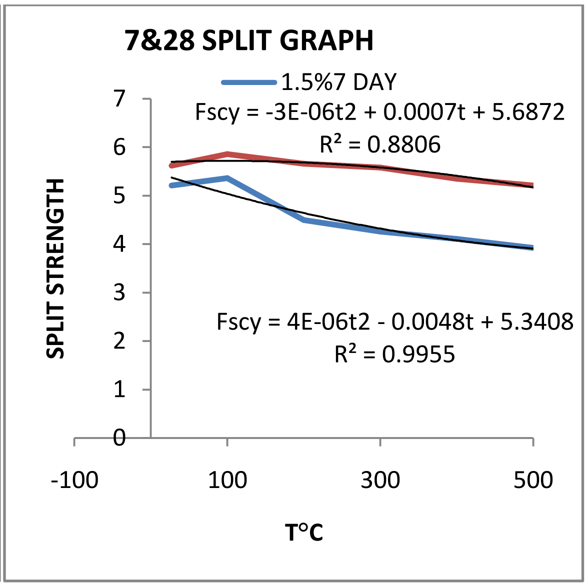



**_Graph 5_** **_Graph 6_**

***Fig.3. Graph .5*** *Split Tensile strength 7 & 28 days strength* ***Graph .6*** *Split Tensile strength 7 & 28 days strength*

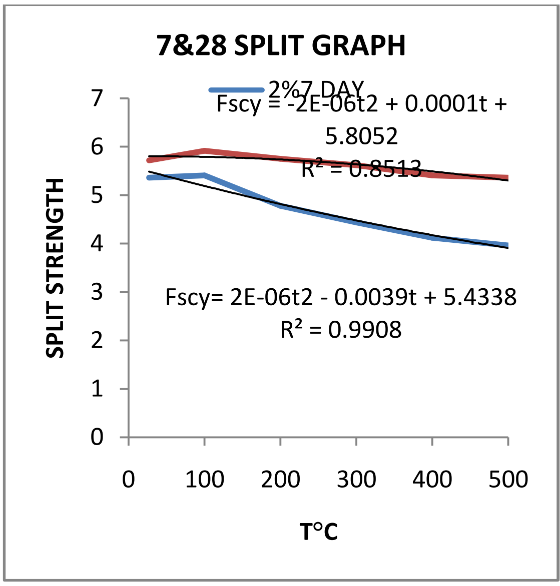


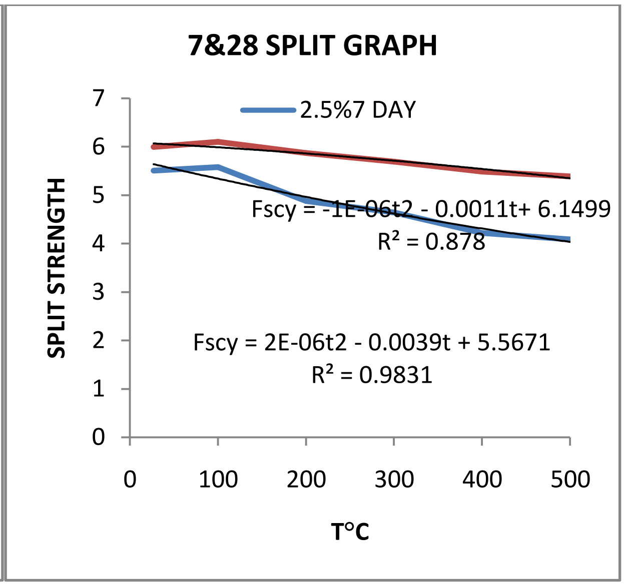




**_Graph 7_** **_Graph 8_**

***Fig.4. Graph .7*** *Split Tensile strength 7 & 28 days strength* ***Graph .8*** *Split Tensile strength 7 & 28 days strength*

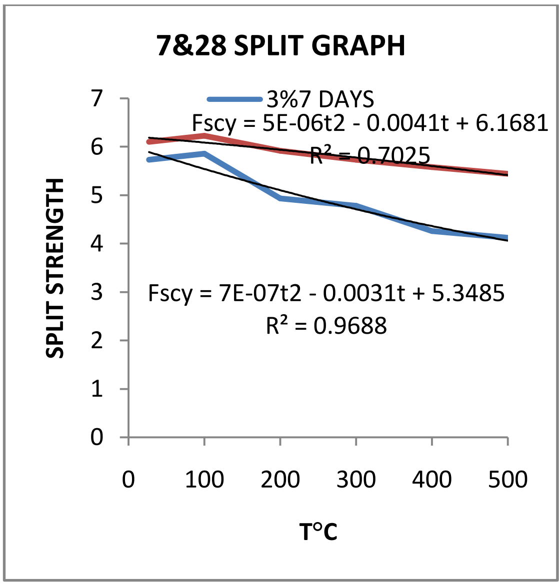
 

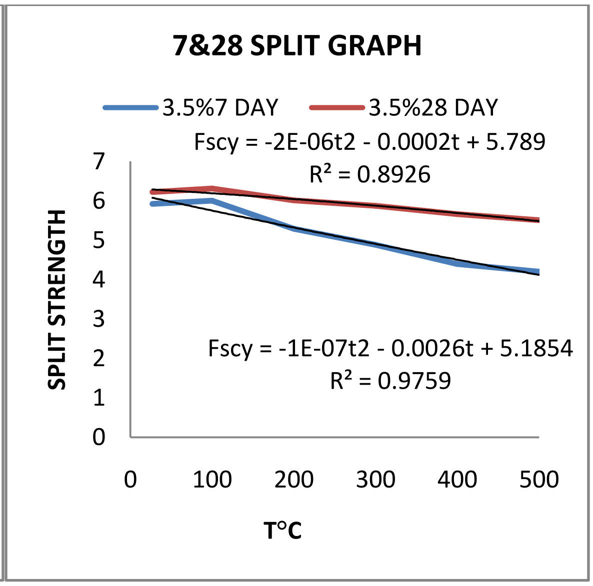



***Graph 9*** ***Graph 10***

***Fig. 5. Graph .9*** *Split Tensile strength 7 & 28 days strength* ***Graph .10*** *Split Tensile strength 7 & 28 days strength*

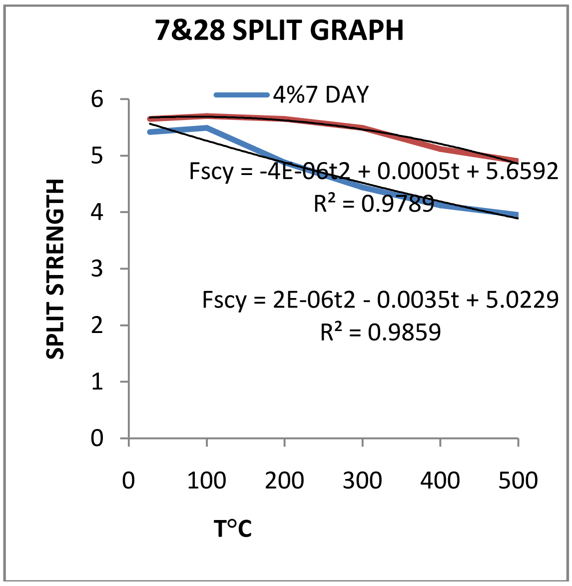


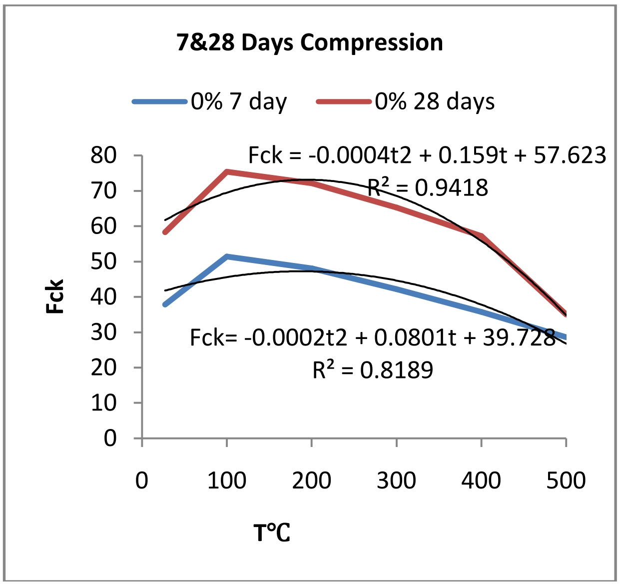




**Graph 11** **Graph 12**

***Fig.6. Graph .11*** *Split Tensile strength 7 & 28 days strength* ***Graph .12*** *Split Tensile strength 7 & 28 days strength*

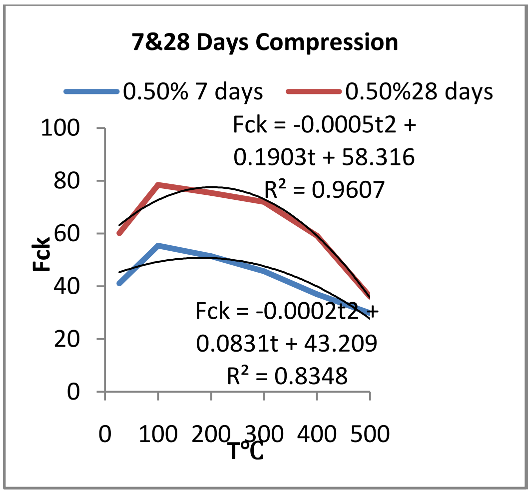
 

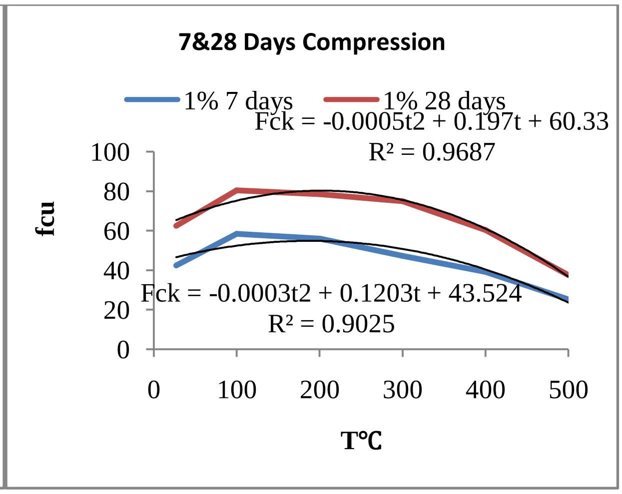



*Graph 13* | *Graph 14*

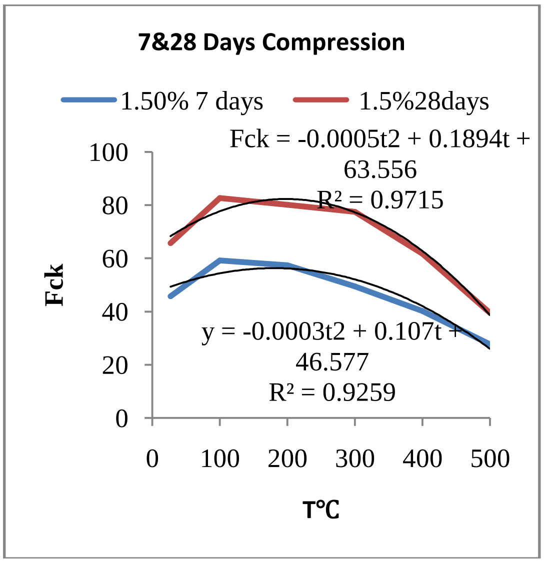
***Fig.7. Graph.13*** *Split Tensile strength 7 & 28 days strength* ***Graph 14*** *Compressive strength 7 & 28 days strength*

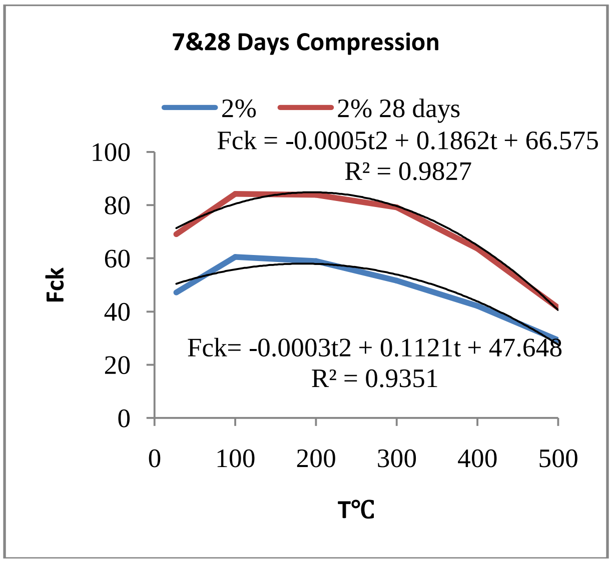



*Graph 15* | *Graph 16*

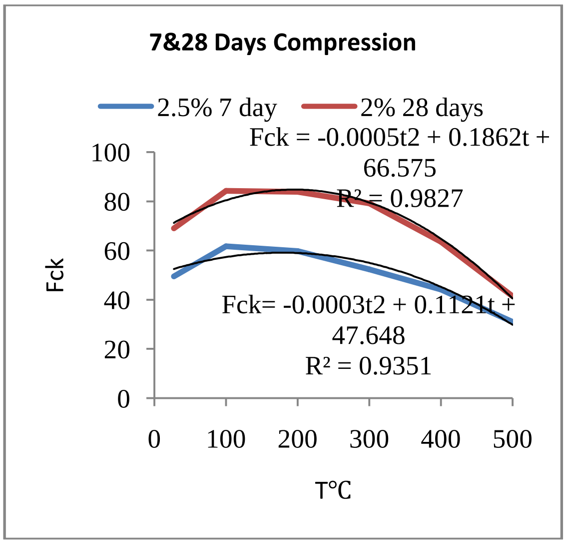
***Fig.8. Graph .15*** *Compressive strength 7 & 28 days strength* ***Graph .16*** *Compressive strength 7 & 28 days strength.*

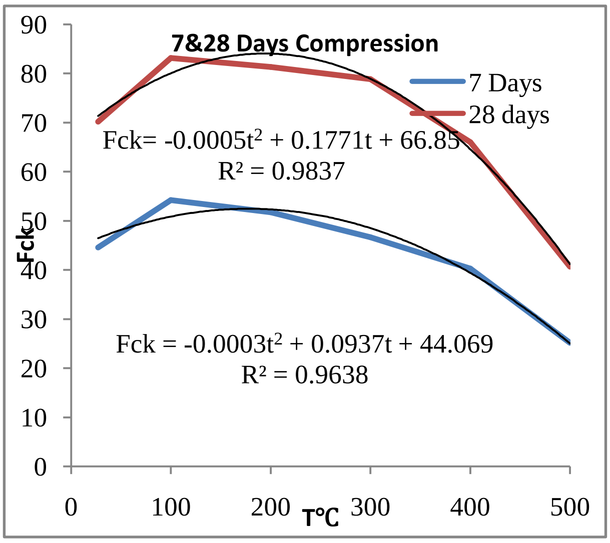



***Graph 17*** ***Graph 18***

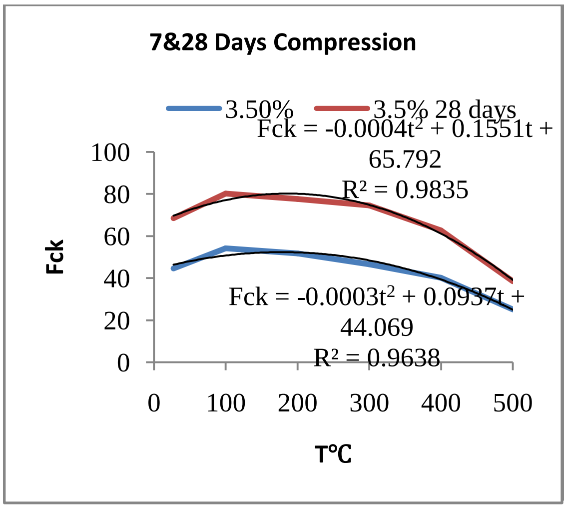
***Fig.9. (Graph .17)*** *Compressive strength 7 & 28 days strength* ***(Graph .18)*** *Compressive strength 7 & 28 days strength*

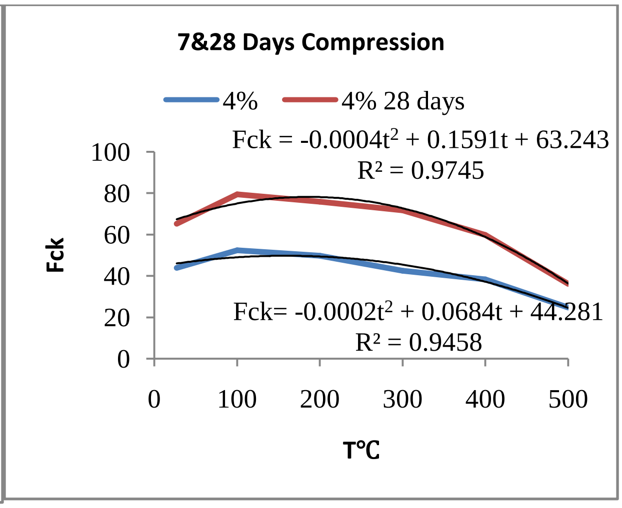



***Graph 19*** ***Graph 20***

***Fig.10. (Graph .19)*** *Compressive strength 7 & 28 days strength* ***(Graph .20)*** *Compressive strength 7 & 28 days strength*




***Graph 21*** ***Graph 22***

***Fig.11. (Graph .21)*** *Compressive strength 7 & 28 days strength* ***(Graph .22)*** *Compressive strength 7 & 28 days strength*

***Table 3*** *Compressive strength by experimental and regression analysis*

| Sr.No | Mix Designation | Steel Fiber in % | Temperature in °C | Compressive strength, $f_{cu}$ (Mpa) | | | |
|---|---|---|---|---|---|---|---|
| | | | | 7 Days | | 28 Days | |
| 1 | $M_0$ | 0 | 27 | 37.82 | 41.74 | 58.27 | 65.53 |
| 2 | $M_1$ | | 100 | 51.38 | 45.74 | 75.42 | 67.34 |
| 3 | $M_2$ | | 200 | 48.04 | 47.75 | 72.13 | 67.01 |
| 4 | $M_3$ | | 300 | 42.13 | 45.76 | 65.2 | 66.29 |
| 5 | $M_4$ | | 400 | 35.73 | 39.77 | 57.2 | 65.41 |
| 6 | $M_5$ | | 500 | 28.62 | 29.78 | 34.98 | 62.7 |
| 7 | $M_6$ | 0.5 | 27 | 41.11 | 46.287 | 60.13 | 67.951 |
| 8 | $M_7$ | | 100 | 55.42 | 47.2 | 78.36 | 70.158 |
| 9 | $M_8$ | | 200 | 51.33 | 46.948 | 75.33 | 69.814 |
| 10 | $M_9$ | | 300 | 45.73 | 46.591 | 71.96 | 69.421 |
| 11 | $M_{10}$ | | 400 | 37.02 | 46.011 | 59.11 | 67.818 |
| 12 | $M_{11}$ | | 500 | 29.87 | 45.513 | 36.04 | 64.525 |
| 13 | $M_{12}$ | 1 | 27 | 42.4 | 48.085 | 62.4 | 70.676 |
| 14 | $M_{13}$ | | 100 | 58.44 | 49.53 | 80.4 | 72.937 |
| 15 | $M_{14}$ | | 200 | 55.91 | 49.312 | 78.4 | 72.702 |
| 16 | $M_{15}$ | | 300 | 47.2 | 48.534 | 74.8 | 72.268 |
| 17 | $M_{16}$ | | 400 | 39.16 | 47.775 | 60.31 | 70.392 |
| 18 | $M_{17}$ | | 500 | 25.11 | 46.356 | 37.42 | 67.002 |
| 19 | $M_{18}$ | 1.5 | 27 | 45.78 | 50.847 | 65.73 | 73.845 |
| 20 | $M_{19}$ | | 100 | 59.24 | 51.863 | 82.62 | 75.791 |
| 21 | $M_{20}$ | | 200 | 57.42 | 51.732 | 80.13 | 75.522 |
| 22 | $M_{21}$ | | 300 | 49.42 | 51.132 | 77.51 | 75.232 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 23 | $M_{22}$ | | 400 | 40.22 | 50.395 | 61.73 | 73.342 |
| 24 | $M_{23}$ | | 500 | 27.73 | 49.313 | 39.42 | 70.245 |
| 25 | $M_{24}$ | 2 | 27 | 47.2 | 52.151 | 69.02 | 76.654 |
| 26 | $M_{25}$ | | 100 | 60.49 | 53.236 | 84.27 | 78.546 |
| 27 | $M_{26}$ | | 200 | 58.93 | 53.096 | 83.82 | 78.285 |
| 28 | $M_{27}$ | | 300 | 51.6 | 52.455 | 79.2 | 78.003 |
| 29 | $M_{28}$ | | 400 | 42.13 | 51.671 | 63.6 | 76.164 |
| 30 | $M_{29}$ | | 500 | 29.2 | 50.526 | 41.42 | 73.138 |
| 31 | $M_{30}$ | 2.5 | 27 | 49.47 | 52.151 | 71.42 | 76.654 |
| 32 | $M_{31}$ | | 100 | 61.73 | 53.236 | 86.13 | 78.546 |
| 33 | $M_{32}$ | | 200 | 59.82 | 53.096 | 85.33 | 78.285 |
| 34 | $M_{33}$ | | 300 | 52.4 | 52.455 | 80.62 | 78.003 |
| 35 | $M_{34}$ | | 400 | 44.22 | 51.671 | 68.44 | 76.164 |
| 36 | $M_{35}$ | | 500 | 31.02 | 50.526 | 42.84 | 73.138 |
| 37 | $M_{36}$ | 3 | 27 | 46.22 | 47.759 | 70.13 | 76.811 |
| 38 | $M_{37}$ | | 100 | 57.02 | 48.436 | 83.11 | 78.115 |
| 39 | $M_{38}$ | | 200 | 54.8 | 48.303 | 81.33 | 77.946 |
| 40 | $M_{39}$ | | 300 | 48.13 | 47.884 | 78.8 | 77.701 |
| 41 | $M_{40}$ | | 400 | 41.42 | 47.435 | 65.96 | 76.356 |
| 42 | $M_{41}$ | | 500 | 27.2 | 46.396 | 40.62 | 73.219 |
| 43 | $M_{42}$ | 3.5 | 27 | 44.53 | 47.647 | 68.53 | 74.542 |
| 44 | $M_{43}$ | | 100 | 54.2 | 48.266 | 80.13 | 75.652 |
| 45 | $M_{44}$ | | 200 | 51.73 | 48.113 | 77.6 | 75.419 |
| 46 | $M_{45}$ | | 300 | 46.62 | 47.785 | 74.62 | 75.138 |
| 47 | $M_{46}$ | | 400 | 40.22 | 47.352 | 62.71 | 73.945 |
| 48 | $M_{47}$ | | 500 | 25.11 | 46.233 | 38.53 | 71.174 |
| 49 | $M_{48}$ | 4 | 27 | 43.82 | 46.894 | 65.11 | 71.906 |
| 50 | $M_{49}$ | | 100 | 52.4 | 47.316 | 79.33 | 73.347 |
| 51 | $M_{50}$ | | 200 | 49.73 | 47.188 | 75.82 | 73.006 |
| 52 | $M_{51}$ | | 300 | 42.44 | 46.824 | 71.6 | 72.584 |
| 53 | $M_{52}$ | | 400 | 38.22 | 46.603 | 59.82 | 71.329 |
| 54 | $M_{53}$ | | 500 | 24.71 | 45.849 | 36.13 | 68.469 |

***Table 4** Split Tensile strengthby experimental and regression analysis*

| **Sr.No** | **Mix Designation** | **Steel Fiber in %** | **Temperature in °C** | **Split Tensile strength, $f_{scy}$(Mpa)** | | | |
|---|---|---|---|---|---|---|---|
| | | | | **Experimental Value** | **From Eq$^{uation}$** | **Experimental Value** | **From Eq$^{uation}$** |
| | | | | **7 Days** | | **28 Days** | |
| 1 | $M_0$ | 0 | 27 | 4.76 | *4.86067* | 5.35 | *5.39374* |
| 2 | $M_1$ | | 100 | 4.88 | *4.86177* | 5.56 | *5.39395* |
| 3 | $M_2$ | | 200 | 4.12 | *4.86355* | 5.39 | *5.39378* |
| 4 | $M_3$ | | 300 | 3.93 | *4.86441* | 5.32 | *5.39371* |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | $M_4$ | | 400 | 3.88 | *4.86463* | 5.15 | *5.39354* |
| 6 | $M_5$ | | 500 | 3.74 | *4.86526* | 4.93 | *5.39332* |
| 7 | $M_6$ | 0.5 | 27 | 4.90 | *4.97989* | 5.42 | *5.47137* |
| 8 | $M_7$ | | 100 | 4.93 | *4.98085* | 5.65 | *5.47157* |
| 9 | $M_8$ | | 200 | 4.30 | *4.98222* | 5.44 | *5.47138* |
| 10 | $M_9$ | | 300 | 4.12 | *4.98293* | 5.38 | *5.47133* |
| 11 | $M_{10}$ | | 400 | 3.95 | *4.98359* | 5.22 | *5.47119* |
| 12 | $M_{11}$ | | 500 | 3.81 | *4.98414* | 4.98 | *5.47097* |
| 13 | $M_{12}$ | 1 | 27 | 5.04 | *5.13891* | 5.51 | *5.5639* |
| 14 | $M_{13}$ | | 100 | 5.10 | *4.98031* | 5.73 | *5.56407* |
| 15 | $M_{14}$ | | 200 | 4.40 | *4.98183* | 5.51 | *5.5639* |
| 16 | $M_{15}$ | | 300 | 4.20 | *4.98261* | 5.44 | *5.56384* |
| 17 | $M_{16}$ | | 400 | 3.98 | *4.98347* | 5.29 | *5.56372* |
| 18 | $M_{17}$ | | 500 | 3.84 | *4.98402* | 5.04 | *5.56352* |
| 19 | $M_{18}$ | 1.5 | 27 | 5.21 | *5.31578* | 5.62 | *5.69112* |
| 20 | $M_{19}$ | | 100 | 5.36 | *5.31711* | 5.86 | *5.69129* |
| 21 | $M_{20}$ | | 200 | 4.50 | *5.31919* | 5.66 | *5.69115* |
| 22 | $M_{21}$ | | 300 | 4.26 | *5.32034* | 5.58 | *5.6911* |
| 23 | $M_{22}$ | | 400 | 4.11 | *5.32107* | 5.35 | *5.69094* |
| 24 | $M_{23}$ | | 500 | 3.92 | *5.32198* | 5.21 | *5.69084* |
| 25 | $M_{24}$ | 2 | 27 | 5.36 | *5.31578* | 5.72 | *5.69112* |
| 26 | $M_{25}$ | | 100 | 5.41 | *5.31711* | 5.92 | *5.69129* |
| 27 | $M_{26}$ | | 200 | 4.78 | *5.31919* | 5.75 | *5.69115* |
| 28 | $M_{27}$ | | 300 | 4.44 | *5.32034* | 5.62 | *5.6911* |
| 29 | $M_{28}$ | | 400 | 4.12 | *5.32107* | 5.41 | *5.69094* |
| 30 | $M_{29}$ | | 500 | 3.96 | *5.32198* | 5.36 | *5.69084* |
| 31 | $M_{30}$ | 2.5 | 27 | 5.51 | *5.5456* | 6.00 | *6.1433* |
| 32 | $M_{31}$ | | 100 | 5.58 | *5.5472* | 6.10 | *6.14304* |
| 33 | $M_{32}$ | | 200 | 4.88 | *5.54806* | 5.87 | *6.14344* |
| 34 | $M_{33}$ | | 300 | 4.64 | *5.549* | 5.69 | *6.14364* |
| 35 | $M_{34}$ | | 400 | 4.22 | *5.55064* | 5.49 | *6.14386* |
| 36 | $M_{35}$ | | 500 | 4.09 | *5.55115* | 5.39 | *6.14397* |
| 37 | $M_{36}$ | 3 | 27 | 5.73 | *5.33193* | 6.10 | *6.14381* |
| 38 | $M_{37}$ | | 100 | 5.86 | *5.33328* | 6.23 | *6.14361* |
| 39 | $M_{38}$ | | 200 | 4.93 | *5.33371* | 5.92 | *6.14463* |
| 40 | $M_{39}$ | | 300 | 4.78 | *5.33427* | 5.73 | *6.14759* |
| 41 | $M_{40}$ | | 400 | 4.26 | *5.33554* | 5.58 | *6.14603* |
| 42 | $M_{41}$ | | 500 | 4.12 | *5.33613* | 5.44 | *6.1464* |
| 43 | $M_{42}$ | 3.5 | 27 | 5.92 | *5.17192* | 6.22 | *5.78785* |
| 44 | $M_{43}$ | | 100 | 6.00 | *5.17289* | 6.31 | *5.78782* |
| 45 | $M_{44}$ | | 200 | 5.29 | *5.17328* | 6.01 | *5.78787* |
| 46 | $M_{45}$ | | 300 | 4.88 | *5.17373* | 5.87 | *5.78788* |
| 47 | $M_{46}$ | | 400 | 4.40 | *5.17477* | 5.66 | *5.78795* |
| 48 | $M_{47}$ | | 500 | 4.20 | *5.17536* | 5.51 | *5.78796* |
| 49 | $M_{48}$ | 4 | 27 | 5.42 | *5.17192* | 5.65 | *5.65636* |
| 50 | $M_{49}$ | | 100 | 5.49 | *5.17289* | 5.70 | *5.65634* |
| 51 | $M_{50}$ | | 200 | 4.88 | *5.17328* | 5.65 | *5.6564* |
| 52 | $M_{51}$ | | 300 | 4.44 | *5.17373* | 5.49 | *5.65644* |
| 53 | $M_{52}$ | | 400 | 4.12 | *5.17477* | 5.12 | *5.65663* |
| 54 | $M_{53}$ | | 500 | 3.95 | *5.17536* | 4.90 | *5.65674* |

## CONCLUSION

The specimens gave maximum percentage increase in compressive strength of steel fiber reinforced concrete was with 2.5% of steel fiber and the specimens casted for split tensile strength gave the highest percentage increase at 3.5% of steel fiber.At 100°C temperature the strength increased abruptly and above 100°C the strength started getting reduces in both split tensile and compression testing. In addition to that the regression analysis for test results of split tensile strength and compressive strength was compared with experimental values and the result not much rehabilitated in both the strengths. As the temperature of the concrete raised beyond 27°C by placing in oven the strength of the concrete increased upto 100°C and get decrease till 500 °Cgradually in compression and split tensile testing .

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